Fisheries and Oceans Canada | Pêches et Océans Canada

Canadian Stock Assessment Secretariat
Research Document 98/103

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Secrétariat canadien pour l'évaluation des stocks
Document de recherche 98/103

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Status of Atlantic salmon (Salmo salar L.) in Campbellton River, Notre Dame Bay (SFA 4), Newfoundland in 1997

by

P. R. Downton and D. G. Reddin
Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's NF A1C 5X1

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ISSN 1480-4883
Ottawa, 1998
Canada

104-06368/

Abstract

The status of Atlantic salmon in Campbellton River in 1997 was determined from the number of salmon counted through a portable fish counting weir (fence) located on the main stem just above head of the tide as well as recreational fishery and biological characteristics data. The assessment was conducted in response to major management changes that were introduced in 1992 and continued in 1993-97. Specifically, there was a moratorium on the commercial Atlantic salmon fishery in insular Newfoundland and restrictions were placed on recreational fishing in each Salmon Fishing Area. The proportion of the conservation egg requirement achieved for Campbellton River in 1997 was 201%. On average for the period of 1993-97, Campbellton River achieved 267% of its conservation requirement. Adult returns averaged 3,015 for small and 287 for large salmon, 1993-97. Historical records indicate that circa. 1800, adult salmon returns to a harvesting weir could have been about 12,000 salmon annually.

Résumé

L'état du saumon de l'Atlantique de la rivière Campbelton en 1997 a été déterminé à partir du nombre de saumons dénombrés à l'aide d'une barrière de comptage portable placée sur le cours principal tout juste en amont de ligne de marée ainsi qu'à partir de données de la pêche récréative et de celles des caractères biologiques. L'évaluation a été effectuée suite à d'importantes modifications apportées à la gestion en 1992 et maintenues de 1993 à 1997. Plus particulièrement, un moratoire a été imposé à la pêche commerciale du saumon de l'Atlantique à l'île de Terre-Neuve et des restrictions ont été imposées à la pêche récréative dans toutes les zones de pêche du saumon. La ponte nécessaire à la conservation a atteint 201 % en 1997 dans la rivière Campbelton. En moyenne, pour la période 1993-1997, les besoins de conservation de la Campbelton ont été atteint à 267 %. Pour cette même période, les remontées moyennes ont été de 3 015 petits saumons et de 287 grands saumons. Les registres indiquent que, vers 1800, les remontées à une pêcherie fixe ont pu atteindre jusqu'à 12 000 saumons adultes par an.

Introduction

The Campbellton River (Indian Arm River) flows in a northeasterly direction emptying into the sea at Indian Arm, Notre Dame Bay. In total, Campbellton River has a drainage area of approximately 296 km□ with an axial length of 40.22 km (Porter et al. 1974) and is about average size for salmon rivers along the northeast coast of insular Newfoundland. The drainage area is also a protected water supply which provides domestic water for the town of Campbellton located at the mouth of the river. The river, located in Salmon Fishing Area (SFA) 4 (Fig. 1), is in a very productive salmon zone (Table 1) which, on average accounts for about 40 percent of all salmon landed by the recreational fishery in the province of Newfoundland. During the early to mid 1980's Campbellton River attracted an annual average of just over 2,000 rod days. However in following years this figure dropped by 50 percent then increased to approximately 1600 rod days (Table 2).

From 1993 to 1997 portable fish counting fences were used to enumerate and monitor salmon migration at various life stages. Also out migrating smolts and kelts in the spring were enumerated and a portion of the kelts tagged to examine the survival rates.

Management Measures

In 1992, a major change was introduced in the management of Atlantic salmon. A five-year moratorium was placed on the commercial fishery in insular Newfoundland while in Labrador, fishing continued under quota. In addition, a commercial license retirement program went into effect in both insular Newfoundland and Labrador. All of these management measures were aimed at increasing river escapements. Also, a moratorium on the Northern Cod Fishery in NAFO Div.'s 2J,3K, and 3L was implemented in early July of 1992 and in Division 3Ps in 1993 which should have resulted in the elimination of salmon by-catch in cod fishing gear in SFAs 1-9 in 1992 and SFAs 10-14A in 1993. The commercial cod fishery moratorium continued in 1997 with exception of a limited commercial fishery in 3Ps and recreational fishery by handlines during several years during the moratorium.

In the recreational fishery, in 1992 and 1993, a quota on the number of fish that could be retained was introduced in each Salmon Fishing Area (SFA). The quota was assigned for an entire SFA and was not administered on an individual river basis. Only hook-and-release fishing was permitted after the quota was caught. In 1994, SFA recreational fishery quotas were eliminated. In place of quotas, for insular Newfoundland, the season bag limit for retained small salmon was lowered from eight to six fish, three to be caught prior to July 31 and three after that date. Hook-and-release fishing was permitted throughout the fishing season. These measures remained in effect in 1997 and applied to salmon angling on Campbellton River. However, due to low salmon returns in 1997 all rivers were closed to retention as of July 28 and then on August 1st both retention and hook and release were closed which remained in effect to the end of the season. As in previous years, retention of large

salmon was not permitted in insular Newfoundland.

In this paper, we examine the status of Atlantic salmon in Campbellton River. Counts obtained from smolt and adult counting fences are used in conjunction with recreational fishery data and biological characteristics data to calculate total river returns and spawning escapements. Stock status is evaluated against a conservation requirement calculated in terms of fluvial and lacustrine habitats.

Methods

RECREATIONAL FISHERY DATA

Catch and effort data for Campbellton River as well as other rivers in Newfoundland and Labrador was collected by Department of Fisheries and Oceans (DFO) Fisheries Officers until 1996 then a license stub return system in 1997 was used. Data for both methods were processed by DFO Science Branch staff. Rivers with counting facilities have angling catches separated above and below the counting facilities where appropriate; however, this was not necessary for Campbellton River since angling does not take place below the counting fence. Procedures for the collection and compilation of recreational fishery data are described by Ash and O'Connell (1987).

UNRECORDED MORTALITIES

Complete understanding of all life history factors including mortality is an important part of any stock assessment (Ricker 1975). Mortality due to fishing but not recorded as part of the catch statistics have been defined as non-catch fishing mortalities (Ricker 1976). Non-catch fishing mortality should include those fish killed due to both illegal and legal fishing activities. Legal fishing mortalities of salmon in Newfoundland and Labrador include catches in food (First Peoples), recreational, sentinel, and commercial fisheries. Illegal mortality includes poaching in both the freshwater and marine environments. Illegal mortalities by their illegal nature are extremely difficult to quantify. An indirect method of observing the effects of illegal removals is by observation of net marks on salmon at enumeration facilities. In 1993-97, occurrences of fish with visible net marks were observed at Campbellton River using the closed circuit video fish-counting system. These observations provide a minimum estimate of the incidence of net-marked fish, since light conditions or minor scarring could render some marks invisible to either the video camera or the naked eye. The incidence of net marks does not quantify unrecorded removals but does provide an indication that mortality of salmon did occur at sea for Campbellton River prior to entering freshwater.

Additional mortality arising from the practice of hook and release fishing is also important for

accurately assessing spawning escapement. To date there have been no definitive hook and release mortality studies on salmon in Newfoundland. However, studies elsewhere have shown that under certain conditions mortality of hook and released 'bright' salmon does occur depending in part on the skill of the angler, method and length of time the fish are handled, length of residence of the salmon in freshwater prior to angling, and water temperature. Recent studies in New Brunswick indicate that rates of 0.1 are possible (Brobbel et al. 1996). Another source of unrecorded mortality is from poaching above the counting fence. Due to the illegal nature of poaching no enumeration of the number of salmon caught illegally on Campbellton River is possible. However, these additional removals potentially result in a lower than indicated number of spawners. Thus, calculations of actual spawners should be regarded as potential.

SMOLT AND ADULT SALMON COUNTS

Standard conduit smolt and adult counting fences were installed according to the description in Anderson and McDonald (1978). The smolt fence was placed in the main stem of the river on May 16 th, 1997 just above the site of the Old Horwood Dam, which was located approximately 300 m upstream from the highway bridge situated at the mouth of the river (Fig. 2). The entire fence is comprised of 36 sections, each 3 m in length, with a standard 2 m * 2 m smolt trap which was installed across a 68 m section of the river on substrate characterized mainly by bedrock with large and small boulders. This site was chosen because it has stable and adequate water levels for fish passage. During the smolt run the trap was checked and fish released on a regular 2-hour basis from 0600 hrs to 2230 hrs. Also, at each trap check several environmental parameters were collected, i.e. water temperature, air temperature, and water level. During the peak smolt run, two 30 cm openings were made in the fence on each side of the smolt trap by removing several conduits. A light colour plywood board was positioned on the substrate to count fish passing through the fence on their downstream migration. After the smolt fence was removed on June 27 th remaining smolts were enumerated from the adult fence until June 30 th. The smolt enumeration is considered a complete count.

The adult fence was situated just below the Old Horwood Dam on a bedrock substrate in a 25 meter wide section of the river (Fig. 2). The fence had 16 sections (3 m long) and a 2 m * 2 m adult trap and was operated from June 12 to September 9. A tunnel with a video camera system (VHS format) was installed in the trap giving an overhead view of salmon moving upstream. The video tape was reviewed the next day to count salmon and the count verified by a second viewing. This system has proven to be very successful since first installed in 1993 and has allowed salmon to move upstream through the fence on a continuous basis, especially during the night when visual monitoring became very difficult at the trap. Use of the camera system seemed to move salmon through the fence more quickly than what would have been the case with a standard trap operation. Also, during daylight hours, a 0.5 m section of the fence next to the trap was opened and monitored manually to facilitate the upstream migration of salmon. The manual counting at the fence site from 1993-97 has accounted from 40-50 % of

upstream migrating salmon. All salmon counted were sized into two categories, viz. small salmon less than 63 cm and large salmon 63 cm or greater. This was done by placing parallel marks 63 cm apart on the floor of the trap/counting device.

SEA SURVIVAL & PREVIOUS SPAWNERS

Sea survival was determined from the number of returning adults in year n+1 and the number of smolts of the preceding year n. The adult salmon counted at the fence consisted of several year classes including salmon spawning for the first time as grilse and salmon that had previously spawned. Thus, sea survival with upstream migrating previous spawners removed from small salmon counts will provide a more accurate measure of sea survival when linked with smolts from the previous year. The number of spawners in the returning adults was determined by mark-recapture. From 1994 to 1997, 33.2 %, 23.9 %, 24.6 % and 15.0 % respectively were marked with a different coloured floy anchor tag for each year, which could be identified by tagging position and colour on the video screen of the counter. Counts of small and large salmon were then adjusted for the number of previous spawners based on the ratio of tagged to untagged in the returning run and the number of outgoing kelts originally tagged. The 3 month survival rates for spawners (kelts) from 1994 to 1997 were 25.58%, 34.85%, 39.42%, and 38.96% respectively.

ENVIRONMENTAL DATA

During field operations, environmental data were collected at both fence sites. Water temperatures were recorded by Hugrun thermograph set at 1 m from the surface at the fence site. Cloud cover, relative water levels, weather conditions and air temperatures were also recorded. Marine temperatures were obtained with a Hugrun thermograph located at a 30 meter depth just off Comfort Cove.

EXPLOITATION RATES

Exploitation rates for the recreational fishery were derived based on the number of small salmon counted at the fence and the number of salmon reported to have been caught by the recreational fishery.

BIOLOGICAL CHARACTERISTICS

Estimated egg depositions in 1993-97 were based on percentage female, mean weights, and fecundity data which were used to convert conservation requirements in eggs to spawning requirements in number of fish and assess the percent of the conservation requirement deposition achieved. The biological characteristics data on adult Atlantic salmon were obtained for Campbellton River by sampling recreational catches in 1993-97. Biological characteristics were collected from the recreational salmon fishery on the Campbellton River in 1992-97 by post-secondary students hired by CEIC through the Challenge Program, under the

guidance of DFO technical staff. These students were responsible for collection of information on fork length, weight, sex, scales and ovaries.

Fecundity was determined from ovaries collected in the recreational fishery. Ovaries were stored in Gilson's fluid until transferred to 10% formalin. Eggs, which for the most part were in early stages of development, were counted directly. The relative fecundity value used to calculate egg deposition for both small and large salmon was 2,100 eggs per kg and was derived from 78 samples taken in Campbellton River, 1993-95.

TOTAL RIVER RETURNS, SPAWNING ESCAPEMENT, AND EGG DEPOSITION

The egg deposition was based on the number of spawning adult salmon and biological information collected from the recreational fishery 1992-97 (Table 3).

Total river returns

Total river returns (TRR) were calculated as follows:

(1) $TRR = RC_b + HRM_b + C$

where,

RC_b = recreational catch below counting fence

HRM_b = hook & release mortalities below counting fence (0.1 of hook & releases)

C = count of fish at counting fence

Spawning escapement

Spawning escapement (SE) was calculated as the difference between the number of fish released from the counting fence (FR), the recreational catch retained above the fence (RC_a) and hook & release mortalities above the fence (HRM_a).

(2) $SE = FR - RC_a - HRM_a$

Egg deposition

Egg deposition (ED) was calculated for small and large salmon as follows:

(3) $ED = SE \times PF \times RF \times MW$

SE = number of spawners
PF = proportion of females
RF = relative fecundity (No. eggs/kg)
MW = mean weight of females

O'Connell and Dempson (1991) reported that unpublished evidence exists demonstrating that atresia (non-development of eggs) occurs to varying degrees in insular Newfoundland salmon. This phenomenon has also been reported in Atlantic salmon in the Soviet Union (Melnikova 1964) and in France (Prouzet et al. 1984). Therefore, fecundity values should be regarded as potential values. Since conservation requirements are based on eggs in early stages of development, the occurrence of atresia in a given year on a particular river would increase the number of spawners required.

CONSERVATION REQUIREMENTS

The accessible parr rearing habitat for Campbellton River is 5,960 units (a unit being 100 m^2) of fluvial habitat and 4037.3 ha of pond habitat (Reddin & Downton 1994). The ratio of lacustrine to fluvial habitat of 67.74 is lower than the mean of 87.11 for other SFA 4 rivers (O'Connell and Dempson 1991). Reddin & Downton (1994) derived potential smolt production for Campbellton River of 46,141 smolts by multiplying the amount of fluvial and lacustrine habitat by production parameter values of 3 smolts per unit (100 m^2) of fluvial habitat and 7 smolts per ha of lacustrine habitat (O'Connell et al. 1991).

The conservation requirements for the Campbellton River of 2,916,126 eggs was derived using egg deposition rates of 240 eggs per 100 m for fluvial parr rearing habitat (Elson 1957) and 368 eggs per ha for lacustrine habitat (O'Connell et al. 1991; Reddin & Downton 1994). Although these values may be habitat and river specific for river systems from which they were derived, they are used to represent a threshold or danger zone to be avoided (O'Connell et al. 1991). Conservation requirements in eggs were converted to adult small salmon by the following formula:

(2,916,126 / ((% female * mean weight * fecundity)

The conservation requirements of spawning adults met for Campbellton River from 1993 to 1997 ranged from 201% to 311% (Appendix 5).

Effects of Moratorium

The moratorium on commercial salmon fishing in insular Newfoundland should have increased spawning escapement in 1992-96 compared to previous years. If this were so for Campbellton

River then the 1996 smolt class consisting of offspring from spawning in 1991 as 4+ smolt and 1992 as 3 + smolt should have increased for the 3 + component. Alternatively, if freshwater survival had changed either by increasing or decreasing then the smolt output would change but the relative proportion of 3+ and 4 + should not. In 1997 the percentage of 3+ and 4+ smolts were somewhat consistent as in 1996 as would be expected. This was examined by comparing the number of smolts after allocating them to their appropriate year classes. The overall sampling base is 1101 or 0.47% smolts from a combined total of 233,374 smolts that migrated to sea, from 1993-97.

Results

RECREATIONAL FISHERY

In 1997, the recreational salmon fishery on Campbellton River had a total of 905 rod days (a rod day being a day or any part thereof in which an individual fishes for salmon) for a retained catch of 238 small salmon (Table 2). The number rod days decreased by 1,059 and retained catch decreased by 225 small salmon compared to 1996. However these low number in rod days and catch are related not only to low returns in 1997 but also to the fishing closures that occurred for 1997. In 1992, the recreational fishery on Campbellton River had 916 rod days and a retained catch of 311 salmon (Table 2). Since then the increases in effort and catch are attributed to anticipated increases in the salmon returns as a result of the closure of the commercial fishery in 1992. In 1997, there were 62 small salmon and 7 large salmon hooked and released. In 1997, the catch (retained plus released) per rod day was 0.34. In 1996, 31 large fish hooked and is the highest since 1975. This would be expected since 560 large fish is the highest number recorded during the counting fence monitoring program after commercial fishery closure.

During the adult fence operation the river was closed to angling 43 meters above the counting fence at the Old Horwood Dam site and below the fence to saltwater. However, a section of the river referred to as the "V" located at the Old Horwood Dam received the most fishing pressure on the lower section of the river. This was mainly due to the easy access from the main highway and relatively good catches at this site. The next site of extensive angling was centered around the lower part of Second Pond resulting from an upgraded forestry road and new bridge constructed in 1992 which provided for easier access to this part of the river. The main stem between Fourth Pond and Indian Arm Pond and the lower portions of Indian Arm Brook and Neyles Brook were the other popular fishing sites for this system. Water temperatures and levels in 1997 were generally good for the first part of the angling season which facilitated a speedy upstream migration for that period, however in mid July to mid August low water levels and high water temperatures occurred. It wasn't until the end of August that heavy rain developed and the end of the upstream migration was seen with the highest number of salmon per day, 122 fish were counted.

UNRECORDED MORTALITIES

At the Campbellton River fence, visible net marks were recorded on a daily basis. Overall in 1997, there were 4.3% or 99 of the 2,296 upstream migrating Atlantic salmon with visible net marks. These marks were observed mainly on the head of the fish, which generally represents scaring that would occur from small mesh nets. Because the Campbellton counting fence is only 0.25 km from the sea, these marks had to have occurred sometime before the salmon entered freshwater. In 1994,1995 and 1996, 6.2% , 5.0% and 4.3 % respectively of the upstream migrating salmon had net marks (O'Connell et al. 1996). It is concluded that there is some mortality at sea due to fishing, although the overall magnitude is unknown.

SMOLT AND ADULT SALMON COUNTS

In 1997, a total of 62,050 smolts and 2,315 kelts passed through the downstream fence along with several other species such as smelt and brook trout (Table 4). The peak of the smolt run occurred in standard week 24 (June 11-17) which accounted for 46.2 percent of the total migration (Table 5). Of the five years for which smolt counts are available, 1997 smolt run was the highest in number. The 1996 smolt run was the earliest to start since the monitoring began in 1993 (Fig. 3). This early run may be attributed to the warmer spring conditions in 1996 and resulting early warmer water temperatures.

In 1997, a total of 1,975 small and 321 large salmon were counted as they passed upstream through the adult fence (Table 6). The first adult salmon was counted on 13 June and the last fish was counted on 8 September. On average week, 25 and 26 accounted for almost 32 percent of the upstream migration, 1993-97 (Table 7). Large salmon returns in 1997 represented 14% of the run and is attributed mainly to the return of previous spawners.

In 1997, the adult counting fence was in operation from 8 June to 8 September (Table 7) and represents a complete upstream count for adult salmon. In 1996 the fence operation stopped as of August 20. Using the small salmon counts from 1993-95 the percent entering after 20 August ranged from 0.6 to 0.8%. If the ratio after August 20 from previous years is applied to the 1996 counts, then there may have been 18 to 27 small salmon entering the river after 20 August, 1996. For large salmon, the percent entering after 20 August ranged from 1.8 to 3.7% which may have resulted in 10 to 21 large salmon entering the river after 20 August, 1996.

Both smolt and adult runs at Campbellton River were considerably earlier in 1996 than in either of the other four years (Figs. 3&4). This was possibly the result of the warmer spring conditions that prevailed in 1996. Consequently, the number of adult salmon that may have entered after the 20 August may be lower than calculated from the run timing that occurred later in previous and subsequent years. Before the adult fence was removed on 20 August, the river downstream from the fence was checked visually for any adult salmon and no salmon

were observed remaining in the river downstream from the fence. Therefore, it is assumed that a complete upstream migration count of adult salmon was achieved in 1996. This visual check was also done for 1997, and no salmon were seen below the fence.

SEA SURVIVAL

Smolt-to-adult survival for the 1997 smolt class from Campbellton River (SFA 4) was 3.38 % (Appendix 4). Estimates of smolt-to-adult survival were 9.05%, 7.28% and 8.08% respectively for years 1993, 1994 and 1995 smolt classes (Appendices 1, 2 and 3). These values are overestimates of survival from smolt to 1SW (grilse) salmon because some of the small salmon migrating upstream are in fact previous spawners that survived from grilse that migrated upstream in previous years. Kelts tagged passing through the downstream smolt fence allowed for correction of the number of previous spawners in the upstream run and calculation of sea survival rates. The results of the tagging study indicated that 33.4% of the small salmon returning to Campbellton River in 1997 were previous spawners. The corrected survival rate after removal of previous spawners is 2.25% which is the lowest percent from 1993-96 (Fig 7.). Thus, sea survival for salmon returning to Campbellton River averaged 5.7%, 1993-96. Over wintering survival of salmon spawning in Campbellton River averaged about 70.6% from 1994-97.

ENVIRONMENTAL DATA

Water temperatures ranged from a low of 6 °C in early April to a peak of about 24 °C in mid-August. Both water temperatures and levels stayed within a comfortable range for salmon during May, June and mid July however after that until the end of August conditions were less favorable to upstream migrations in 1997 (Fig. 5).

Marine temperatures from Comfort Cove ranged from -1.2 to 14.6 C^0 from mid April to the end of October. Although the combined daily mean sea temperatures from 1989-95 and 97 are similar, the 1996 mean is higher which may be attributed to the early spring for that year.

EXPLOITATION RATES

In 1997, a total of 1,975 small salmon passed through the counting fence and there was a catch of 238 small and large salmon (retained & released) by the recreational fishery above the fence. There were no salmon caught below the fence. The exploitation rate in the 1997 recreational fishery was 13.4% (95% CI=11.0%, 15.2%). Overall exploitation has been increasing on Campbellton River, 1993-96. Exploitation on small salmon (retained only) has almost doubled between 1993 and 1996 except in 1997 when the fishery was closed due to low returns. Exploitation on the total population has increased by about 50% from 1993 to 1996. Rod days have increased from 1,355 in 1993 to 1,964 in 1996.

Exploitation rates are in the following text table:

Year	Small retained	Small ret. + rel.	Large released	Total
1993	7.9%	10.5%	0.0%	10.1%
1994	11.9%	12.0%	0.5%	11.3%
1995	12.9%	14.5%	0.5%	13.6%
1996	14.4%	17.3%	5.5%	15.6%
1997	12.1%	15.2%	2.2%	13.4%

BIOLOGICAL CHARACTERISTICS

The river ages of smolts sampled at the counting fence ranged from 2 to 6 years with age 3 smolt being the predominate age class (Table 8). The number of river age 3 and 4 smolts in the 1996 and 1997 smolt migration increased from the 1993-95 average of 21,864 and 14,019, to 34,479 and 20,359 in 1996, and 35,679 and 24,547 in 1997. The smolt run doubled from 31,577 in 1993 to 62,050 in 1997. The overall mean run for 1993-97 was 46,675.

From 1993 to 1996, 231 adult salmon were sampled from the recreational fishery. Overall mean fork length of the grilse-only fishery for the Campbellton River was 52.8 cm and 76.4 % of aged fish had a freshwater life of 3 years (Tables 9 & 10). Twenty-four fish that were sampled during 1992-97 had previously spawned and were within the fork length set for retention in the recreational fishery. Also, two fish were sampled that returned to freshwater in the same summer that they went to sea as smolts.

The percentage of female salmon sampled from the recreational fishery in 1992-97 was 75.98% (Table 11). The mean weight for female small salmon was 1.51 kg (N=150 and SD=0.27). There were no samples for large salmon available from Campbellton River due to the mandatory release of large salmon in the recreational fishery introduced in 1984. Default values for mean weight and percent female of large salmon 3.13 and 76.9 were used that were derived from several rivers in SFA 4 (O'Connell et al. 1996).

Approximately 0.5% of the smolt migration was sampled each year 1993-97. The mean fork length and whole weight was slightly higher for female smolt (Table 12). The overall mean fork length and whole weight was 174 mm and 49.0 grams, respectively and had a mean age of 3.45 years.

ACCURACY OF EGG DEPOSITION ESTIMATES

The precision of annual egg deposition values was examined by deriving egg depositions from the biological characteristics of the upstream migrating adults sampled in the angling fishery compared to that derived from downstream migrating kelts measured at the smolt fence in the following year. If the number of samples are adequate to define biological characteristics of either group then the egg depositions from the two methods should be similar. Egg depositions from kelts are based on the number of eggs per cm whereas eggs per kg are used for the upstream migrating salmon. Comparison of values derived on fresh run versus kelts shows 312% versus 304% in 1993, 239% versus 220% in 1994, and 279% versus 256% in 1995 (Table 13 a & b). Because the percentage of conservation requirements achieved is always slightly higher when based on fresh run salmon suggests there may be a tendency to overestimate rather than underestimate the percent of conservation requirements achieved. However, the similarity of the two values suggests that the tendency to overestimate is small.

SALMON POSTSMOLTS RETURNING TO FRESHWATER

Stocks of Atlantic salmon exhibit various life history patterns including several alternate strategies. The entire life cycle can take place in freshwater; they can start life in the river, then migrate between river and estuary; they can migrate between river and estuary and then go to sea; or they can have the more typical anadromous life cycle of going to sea for one or more years before returning to freshwater (Power et al. 1987). In Newfoundland and Labrador, salmon migrate to sea at two to seven years of age and then return to freshwater after spending at least one or more years in the sea. Salmon that have spawned one or more times after one or more years in the sea are also quite common. As evidenced by scale reading of a few salmon sampled that were caught by anglers or at enumeration facilities, a small minority of salmon exist that spend only a couple of months at sea before returning to freshwater. Because they do not spend a full year at sea, these salmon are typically very small being less than 40 cm fork length. Also, as they are uncommon the salmon nomenclature does not have a separate name for this life stage and they would be labelled as postsmolts (Allan and Ritter 1977).

In 1995, anglers reported for a number of rivers, e.g. Southwest Brook in Bay St. George, observing a high number of very small salmon migrating upstream. In 1993 and 1994, a few very small (<40 cm) salmon were noted at the counting fence ascending Campbellton River. In the spring of 1994, several of these small salmon were sampled as kelts descending through the smolt counting fence. In total, out of 907 kelts sampled there were four or 0.4% that had not completed a full year in the sea. Another 12 or 1.4% of the kelts had no complete sea year but showed 2 or more spawning marks but remains a relatively minor component of the run.

In 1995, a 30 cm line was installed in the tunnel of the video counting chamber in the adult counting fence in Campbellton River to better enable enumeration of these fish. In 1995, 13 salmon of approximately 28-35 cm in length were observed ascending through the Campbellton

River counting fence. The total upstream run was 13 postsmolts, 3,035 small and 218 large salmon; thus, the upstream run consisted of 0.4% postsmolts. Therefore, it is concluded that for 1995, the presence of salmon postsmolts in the upstream run at Campbellton River is not unusual in that it also occurred in other years but remains a relatively minor component of the run.

TOTAL RIVER RETURNS, SPAWNING ESCAPEMENT, AND EGG DEPOSITION

Total river returns

Target spawning requirements and potential smolt production

The estimated conservation requirements for Campbellton River in terms of eggs as well as adult salmon were estimated as follows:

	Lacustrine	Fluvial	Total
Accessible habitat	4037.3 ha	5,960 units	-
Eggs (No. x 10^6)	1.486	1.430	2 916 126

Conservation requirements converted to numbers of small salmon (Reddin and Downton 1994):

$$= \frac{2{,}916{,}126 \text{ eggs}}{(\% \text{ female} * \text{mean wt} * \text{fecundity})}$$

$$= \frac{2{,}916{,}126}{(0.745 * 1.493 * 1775)}$$

= **1480 small salmon**

Estimated potential smolt production are as follows:

Fluvial smolt	= 3 smolts/unit * 5960 units	= 17,880
Lacustrine smolt	= 7 smolts/ha * 4,037.3 ha	= 28,261
Total potential smolt production		= 46,141

Effects of Moratorium

The smolt count at Campbellton in 1997 of 62,050 increased appreciably over that of the previous three year average 1993-95 of 37,652, and by 3,500 fish from the total in 1996 (Table 5). For this increase to have been solely due to the effects of the moratorium on the commercial salmon fishery in insular Newfoundland then the increase in smolts should have been mainly 3+ river age to have been from the 1992 spawning class. Since the increase was

derived from the 3+ and 4+ smolts in 1996 and 1997 suggests that it may be due to an increase in freshwater survival rather than an increase in spawning or possibly both.

Discussion

Taylor (1985) discussed the historical catch record for many rivers in Newfoundland and Labrador. He states that because of relatively high Atlantic salmon abundance in the Campbellton River, it was valuable to the Beothucks and Europeans alike. The earliest catch record specific to Campbellton indicates that a John Ginn landed 90 tierces of salmon in one year, on or about the year 1816. Because the early European settlers fished by placing a weir across the entire river and there was no coastal gillnet fishery, these catches are an approximation of total production of the river when it was in a pristine state. The 90 tierces converts to 18,400 kg using the conversion factors of Taylor (1985). This weight of fish converts to about 12,000 salmon if the mean weights of 1993-96 period are used. The highest count in the 1993-97 period is 4,146 or about 30% of that which Campbellton River may have produced when it was in a more natural state.

At the conservation requirement of 1,480 spawners there is anticipated to be about 48,000 smolts produced from Campbellton River. At average survival rates and relative proportions of large salmon, 48,000 smolts should produce about 4,600 adult salmon. If Campbellton River still has similar freshwater habitat to what was present in 1816 then perhaps the difference between the 4,600 adult salmon produced at conservation requirements which is intended to represent a threshold level, and the 12,000 salmon it produced in a more virgin state could provide some reference to a potential maximum production. Since the percent of the conservation requirement achieved on average for Campbellton, 1993-97 is about 267% it would be interesting and potentially very informative to be able to monitor adult returns in 1998-2001. Alternately, the presumed historic production of 12,000 salmon may have represented an extreme maximum value.

For Campbellton River, there was no detailed habitat survey available (Porter et al. 1974). Thus, the habitat values given in this paper should be regarded as preliminary and will be subject to further review. The Campbellton River watershed has had extensive logging activity in the past. Especially in the early 1900's when a 400 m long, 10 m high dam was erected by the Horwood Lumber Company near the mouth of the river to divert water into a 350 m rock-cut channel to run a pulp mill and hydro plant. At this time this Horwood Lumber Co. had timber rights to 596 km□ and used the river as a means to float logs to the mill. However, this operation was short lived since the dam broke in 1916 and the company went into bankruptcy. Logging continued in and around the Campbellton River up to 1966 when 22 small dams were removed by Price (Nfld.) Ltd. under the supervision of the Department of Fisheries and Oceans. The structures from these historical logging activities are still visible in the remains of dams and tree trunks scattered at various points along the river. The remains of several dams located on the Crooked Brook tributary, which empties into Second Pond, still pose

partial obstructions to migrating salmon during low water levels. In 1961, the upper watershed near Shirley Lake and Silt Lake was completely destroyed by fire, which only now has returned to a normal forest growth. The effect of these activities on the production of salmon in the system are unknown.

Since the habitat in Campbellton River has not been completely surveyed the conservation requirement may be an over- or under-estimate. The total number of adult salmon spawning in 1997 resulted in an egg deposition that was 201% over conservation requirements. It was noted during the helicopter survey that many of the spawning areas on the main stem were located between relatively small and shallow ponds. These shallow ponds may provide for an optimal utilization of rearing habitat and a higher rearing capacity much closer to that of the classical fluvial habitat may be more appropriate. Therefore, caution must be used when referring to conservation requirements until a full habitat survey is completed.

In 1992, a forestry access road was built from the main highway (Route 340) into the watershed of Campbellton River at a location known as Pine Pool which is situated between 2nd and 3rd Pond. Approximately, 30,000 cords of timber have been cut for Abitibi Consolidated. The agreement between Abitibi and the Province of Newfoundland expires in 1998, with the further 5,000 cords to be cut (Personal communication, Cal Smart, Dept. of Forestry and Agrifoods). Although, the nature of any effect of forest cutting on salmonid production is unknown there could be a significant impact on the fish of the Campbellton watershed from this activity.

For Campbellton River, the smolt production of 62,050 for 1997 is 134% above the calculated potential smolt production of 46,141. The modal smolt age for Campbellton River salmon is 3 years and thus, the 1997 smolt run is derived mainly from adults that spawned in the fall of 1993. For most Newfoundland rivers, spawning escapements in 1997 were the lowest on record in the period 1989-91 (Dempson and O'Connell 1993). Escapements on northeast coast Newfoundland rivers rose beginning in 1992 with the beginning of the commercial salmon fishing moratorium and smolt production stemming from spawning escapements in post-moratorium years may be much closer to this potential figure.

Assumptions associated with the parameter values used to calculate the conservation spawning requirement have been discussed previously by O'Connell et al. (1991), O'Connell and Dempson (1991), O'Connell and Ash (1994) and will not be dealt with in detail here. The comments in O'Connell and Ash (1994) on further substantiation of parameter values for calculations related to egg deposition apply as well to Campbellton River. Also, it should be kept in mind that inaccuracies in catch statistics, losses to due poaching, losses due to hook and release mortality, and losses from natural mortality will influence the results.

Acknowledgments

The project was funded by a grant from Human Resources Development Canada, under the Job Creation Program to the Lewisporte Area Development Association (LADA). The assistance of the following persons is gratefully acknowledged: DFO Resource Management Branch, Twillingate, the field staff provided by LADA, and Mr. R. Johnson, DFO Science Branch.

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Table 1. The total rod days, total catch and catch per unit effort (CPUE) for Atlantic salmon retained in the recreational fishery for Insular Newfoundland ,Salmon Fishing Area 4 and the Campbellton River from 1953 to 1997.

Year	Rod days			Total catch (retained + released)			CPUE		
	Insular NFLD	SFA 4	Campbellton River	Insular NFLD	SFA 4	Campbellton River	Insular NFLD	SFA 4	Campbellton River
1953	27,955	8,630	346	8,226	3,485	126	0.29	0.40	0.36
1954	16,974	7,344	587	3,630	1,600	102	0.21	0.22	0.17
1955	11,183	5,125	56	5,098	2,616	61	0.46	0.51	1.09
1956	33,532	10,672	341	8,269	4,350	119	0.25	0.41	0.35
1957	17,514	8,789	291	8,617	4,950	105	0.49	0.56	0.36
1958	16,593	5,888	592	10,054	5,001	447	0.61	0.85	0.76
1959	17,570	6,321	325	8,685	4,220	303	0.49	0.67	0.93
1960	17,530	7,051	313	7,366	3,950	265	0.42	0.56	0.85
1961	13,730	5,277	209	4,778	2,280	146	0.35	0.43	0.70
1962	21,641	8,842	397	9,912	4,879	147	0.46	0.55	0.37
1963	26,824	10,910	1,242	10,673	4,042	421	0.40	0.37	0.34
1964	34,886	15,608	1,066	16,281	7,917	496	0.47	0.51	0.47
1965	34,083	13,749	647	12,443	4,551	468	0.37	0.33	0.72
1966	34,073	15,249	881	13,745	6,627	689	0.40	0.43	0.78
1967	38,067	13,915	815	9,569	4,226	487	0.25	0.30	0.60
1968	40,004	15,318	1,577	16,616	6,139	743	0.42	0.40	0.47
1969	40,347	13,807	992	16,470	4,138	534	0.41	0.30	0.54
1970	38,933	15,759	660	15,665	4,896	437	0.40	0.31	0.66
1971	38,417	11,379	622	13,151	3,841	299	0.34	0.34	0.48
1972	33,487	10,778	452	12,798	3,468	210	0.38	0.32	0.46
1973	46,180	14,544	1,344	19,450	6,759	971	0.42	0.46	0.72
1974	67,894	22,038	1,956	15,689	5,455	505	0.23	0.25	0.26
1975	60,191	22,384	1,768	16,304	6,109	487	0.27	0.27	0.28
1976	64,853	24,787	2,042	16,722	6,871	834	0.26	0.28	0.41
1977	69,057	28,117	2,134	22,561	9,482	912	0.33	0.34	0.43
1978	63,599	24,131	1,314	20,339	9,276	429	0.32	0.38	0.33
1979	50,199	21,496	53	18,228	8,353	23	0.36	0.39	0.43
1980	66,625	25,172	2,293	24,093	9,921	1,112	0.36	0.39	0.48
1981	77,884	32,282	2,950	30,980	13,897	1,549	0.40	0.43	0.53
1982	85,200	32,929	1,674	26,518	10,231	473	0.31	0.31	0.28
1983	82,167	26,649	1,619	22,311	9,251	597	0.27	0.35	0.37
1984	79,740	29,633	2,657	24,878	9,915	992	0.31	0.33	0.37
1985	82,783	34,329	3,219	26,527	12,190	782	0.32	0.36	0.24
1986	79,009	31,650	1,791	24,182	9,293	422	0.31	0.29	0.24
1987	47,809	18,564	803	13,013	5,453	169	0.27	0.29	0.21
1988	73,566	27,413	1,837	23,960	9,854	636	0.33	0.36	0.35
1989	53,862	17,767	854	11,525	3,786	148	0.21	0.21	0.17
1990	64,494	23,533	693	17,409	5,661	106	0.27	0.24	0.15
1991	52,173	21,999	693	11,132	4,892	126	0.21	0.22	0.18
1992	39,242	19,485	916	12,271	6,810	341	0.31	0.35	0.37
1993	58,943	30,598	1,355	14,947	13,114	419	0.25	0.43	0.31
1994	141,508	43,242	1,484	39,381	12,158	345	0.28	0.28	0.23
1995	143,275	36,717	1,775	40,818	11,329	441	0.28	0.31	0.25
1996	156,631	44,385	1,964	53,179	17,566	587	0.34	0.40	0.30
1997	54,902	13,835	905 *	35,459	5,786	307 *	0.65	0.42	0.34 *
Mean	53,670	19,513	1,167	17,643	6,902	452	0.35	0.38	0.44
Mean percent of Island		36.4%	2.2%		39.1%	2.6%			
Mean percent of SFA			5.98%			6.54%			

* Note angling fishery was closed on July 28 for SFA 4 therefore effort is only a partial figure.

Table 2. Atlantic salmon recreational statistics for Campbellton River, Notre Dame Bay, SFA 4, 1974-97.

River: Campbellton River Code: 0708210

Year	Effort Rod Days	Small (<63 cm) Ret.	Rel.	Tot.	Large (>=63 cm) Ret.	Rel.	Tot.	Total (Small + Large) Ret.	Rel.	Tot.	CPUE
1974	1956	505	.	505	0	.	0	505	.	505	0.26
1975	1768	424	.	424	63	.	63	487	.	487	0.28
1976	2042	834	.	834	0	.	0	834	.	834	0.41
1977	2134	895	.	895	17	.	17	912	.	912	0.43
1978	1314	426	.	426	3	.	3	429	.	429	0.33
1979	53	23	.	23	0	.	0	23	.	23	0.43
1980	2298	1112	.	1112	0	.	0	1112	.	1112	0.48
1981	2950	1547	.	1547	2	.	2	1549	.	1549	0.53
1982	1674	471	.	471	2	.	2	473	.	473	0.28
1983	1619	597	.	597	0	.	0	597	.	597	0.37
1984	2657	991	.	991	1	.	1	992	.	992	0.37
1985	3219	782	.	782	*	.	0	782	.	782	0.24
1986	1791	422	.	422	*	.	0	422	.	422	0.24
1987	803	169	.	169	*	.	0	169	.	169	0.21
1988	1837	636	.	636	*	.	0	636	.	636	0.35
1989	854	148	.	148	*	.	0	148	.	148	0.17
1990	693	106	.	106	*	.	0	106	.	106	0.15
1991	693	126	.	126	*	.	0	126	.	126	0.18
1992	916	311	30	341	*	0	0	311	30	341	0.37
1993	1355	316	103	419	*	0	0	316	103	419	0.31
1994	1484	340	4	344	*	1	1	340	5	345	0.23
1995	1775	393	47	440	*	1	1	393	48	441	0.25
1996	1964	463	93	556	*	31	31	463	124	587	0.30
1997	907 **	238	62	300	*	7	7	238	69	307	0.34
84-89 $\bar{X}$	2071.6	595.8	.	595.8	.	.	.	596.0	.	596.0	0.29
95% CL	1123.4	403.8	.	403.8	.	.	.	404.2	.	404.2	0.00
N	5	5	0	5	0	0	0	5	0	5	5
86-91 $\bar{X}$	1173.6	287.6	.	287.6	.	.	.	287.6	.	287.6	0.25
95% CL	730.6	289.8	.	289.8	.	.	.	289.8	.	289.8	0.00
N	5	5	0	5	0	0	0	5	0	5	5
92-96 $\bar{X}$	1498.8	364.6	55.4	420.0	.	6.6	6.6	364.6	62.0	426.6	0.28
95% CL	501.7	79.3	52.1	109.1	.	16.9	16.9	79.3	62.1	124.1	0.00
N	5	5	5	5	0	5	5	5	5	5	5

1987 DATA NOT INCLUDED IN MEAN

IN THE ABOVE TABLE A PERIOD INDICATES NO DATA FOR THAT YEAR

CPUE IS BASED ON RETAINED + RELEASED FISH FOR 1992 - 1996 AND ON RETAINED FISH ONLY PRIOR TO 1992

* NOT ALLOWED TO RETAIN LARGE SALMON IN INSULAR NEWFOUNDLAND

THE 1997 DATA WAS DERIVED FROM THE 1997 LICENCE STUB RETURN

** ONLY REPRESENT A PARTICAL FIGURE SINCE THE RECREATIONAL FISHERY WAS CLOSED ON JULY 28

Table 3. Campbellton River adult salmon returns, spawning escapment and egg deposition, 1993-97.

SPAWNING ESCAPEMENT $SE = (FR - RCT) - (HRM)$

SE= Spawning escapment
FR= Fish released by counting fence
RCT= Recreational catch (retained)
RCL= Recreational catch (released)
HRM= Recreational mortality (RCL *0.1)

		1993	1994	1995	1996	1997	Average
FR	Small	4001	2857	3035	3208	1975	3275.3
	Large	145	191	218	560	321	278.5
RCL	Small	103	4	47	93	62	61.8
	Large	0	1	1	31	7	8.0
HRM	Small	10.3	0.4	4.7	9.3	6.2	6.2
	Large	0.0	0.1	0.1	3.1	0.7	0.8
RCT	Small	316	340	393	463	238	350.0
	Large	0	0	0	0	0	0.0
SE	Small	3674.7	2516.6	2637.3	2735.7	1730.8	2919.1
	Large	145.0	190.9	217.9	556.9	320.3	277.7

EGG DEPOSITION $ED = SE * PF * RF * MW$

ED= Egg deposition
SE= Spawning escapment
PF= Proportion females
RF= Relative fecundity (eggs/kg)
MW= Mean weight of females

		YEAR					
	Year	1993	1994	1995	1996	1997	AVERAGE
SE	Small	3674.7	2516.6	2637.3	2735.7	1730.8	2659
	Large	145.0	190.9	217.9	556.9	320.3	286
PF	Small	0.7356	0.7273	0.8182	0.6667	0.818	0.753
	Large	0.769	0.769	0.769	0.769	0.769	0.769
RF	Small	2100	2100	2100	2100	2100	2100
	Large	2100	2100	2100	2100	2100	2100
MW	Small	1.470	1.560	1.550	1.580	1.43	1.518
	Large	3.13	3.13	3.13	3.13	3.13	3.13
ED	Small	8,344,498.5	5,996,138.7	7,023,765.5	6,051,671.0	4,251,630.6	6,384,103.5
	Large	732,922.4	964,930.2	1,101,405.4	2,814,927.3	1,619,000.2	1,446,637.1
Total		9,077,420.8	6,961,068.9	8,125,170.9	8,866,598.3	5,870,630.8	7,830,740.6
Conservation requirements		2,916,000	2,916,000	2,916,000	2,916,000	2,916,000	2,916,000
% requirements		311.3	238.7	278.6	304.1	201.3	268.5

The PF and MW for large salmon are default values calculated from several rivers in Notre Dame Bay (O'Connell etal 1996).

Table 4. Daily count of downstream migrating fish at Campbellton River through the counting fence in 1997.

Date	Parr	Smolt	Kelt	Ouananiche	P.P. Smolt	Trout	Smelt	Eel
18-May-97	1	5	0	0	0	0	1	0
19-May-97	11	7	18	0	3	21	2	0
20-May-97	4	8	11	0	0	8	1	0
21-May-97	12	8	8	0	1	8	0	0
22-May-97	5	10	47	0	0	5	1	0
23-May-97	3	9	37	0	0	11	3	0
24-May-97	11	24	54	1	0	13	4	0
25-May-97	2	15	9	0	0	16	3	0
26-May-97	3	17	8	0	0	16	0	0
27-May-97	1	7	4	0	0	3	0	0
28-May-97	4	17	126	0	1	13	4	0
29-May-97	14	87	31	0	4	21	3	0
30-May-97	20	121	178	0	3	16	4	0
31-May-97	25	327	137	0	5	50		0
01-Jun-97	33	913	166	1	5	46	1	0
02-Jun-97	42	702	44	0	3	28	1	0
03-Jun-97	16	324	101	0	0	9	3	0
04-Jun-97	11	289	62	0	0	10	1	0
05-Jun-97	9	324	23	0	0	9	1	0
06-Jun-97	12	367	18	1	3	9	5	0
07-Jun-97	3	485	26	0	0	13	4	0
08-Jun-97	6	1592	99	0	2	13	7	0
09-Jun-97	13	6172	132	1	7	36	4	0
10-Jun-97	12	4788	36	0	3	41	14	1
11-Jun-97	5	3073	81	0	2	20	10	0
12-Jun-97	5	3496	87	0	1	9	13	0
13-Jun-97	5	3270	49	0	1	6	33	0
14-Jun-97	7	8777	177	1	1	14	27	3
15-Jun-97	9	4191	56	0	1	9	15	0
16-Jun-97	5	4032	115	0	1	13	33	0
17-Jun-97	1	1802	21	0	0	2	13	0
18-Jun-97	4	5460	37	0	1	13	24	0
19-Jun-97	4	2960	17	0	0	10	37	0
20-Jun-97	2	2229	67	0	0	5	34	0
21-Jun-97	0	1639	87	0	0	1	57	1
22-Jun-97	7	1401	35	0	0	0	44	0
23-Jun-97	0	792	43	0	0	1	22	0
24-Jun-97	1	427	15	0	1	2	28	0
25-Jun-97	4	723	13	0	0	0	45	0
26-Jun-97	6	631	16	0	0	0	46	0
27-Jun-97	2	328	22	0	0	2	51	0
28-Jun-97	1	90	0	0	0	0	3	0
29-Jun-97	0	58	2	0	0	0	0	0
30-Jun-97	0	24	0	0	0	0	150	0
01-Jul-97	0	29	0	0	0	0	0	0
Total	341	62,050	2,315	5	49	522	752	5

Table 5. Smolt migration by standard week through the counting fence on the Campbellton River, 1993-97.

Dates		Standard week	Year and percent										Mean
			1993	%	1994	%	1995	%	1996	%	1997	%	
April	23-29	17	0	0.00	0	0.00	0	0.00	44	0.08	0	0.00	9
May	30-06	18	0	0.00	1	0.00	0	0.00	2,146	3.68	0	0.00	429
	07-13	19	0	0.00	16	0.04	3	0.01	3,152	5.40	0	0.00	634
	14-20	20	125	0.40	224	0.54	15	0.04	14,833	25.41	20	0.03	3,043
	21-27	21	6,607	20.92	2,137	5.13	826	2.08	14,243	24.40	90	0.15	4,781
	28-03	22	7,071	22.39	7,842	18.84	8,228	20.72	13,358	22.89	2491	4.01	7,798
June	04-10	23	9,915	31.40	17,297	41.55	14,409	36.28	8,264	14.16	14017	22.59	12,780
	11-17	24	4,518	14.31	12,091	29.04	11,566	29.12	2,156	3.69	28641	46.16	11,794
	18-24	25	3,012	9.54	1,876	4.51	4,020	10.12	121	0.21	14908	24.03	4,787
	25-01	26	253	0.80	147	0.35	495	1.25	52	0.09	1883	3.03	566
July	02-08	27	76	0.24	32	0.08	98	0.25	0	0.00	0	0.00	41
	09-15	28	0	0.00	0	0.00	55	0.14	0	0.00	0	0.00	11
Total			31,577		41,663		39,715		58,369		62,050		46,675

Table 6. The upsteam migration of Atlantic salmon through the counting fence on Campbellton River , 1997.

Date	Small	Large	Total
13-Jun	0	0	0
14-Jun	0	2	2
15-Jun	3	2	5
16-Jun	7	0	7
17-Jun	6	2	8
18-Jun	12	2	14
19-Jun	15	1	16
20-Jun	19	0	19
21-Jun	63	4	67
22-Jun	38	2	40
23-Jun	66	4	70
24-Jun	104	3	107
25-Jun	51	1	52
26-Jun	27	1	28
27-Jun	45	3	48
28-Jun	106	5	111
29-Jun	93	1	94
30-Jun	81	0	81
01-Jul	47	1	48
02-Jul	36	0	36
03-Jul	68	0	68
04-Jul	41	0	41
05-Jul	35	0	35
06-Jul	43	0	43
07-Jul	39	1	40
08-Jul	22	0	22
09-Jul	18	2	20
10-Jul	11	1	12
11-Jul	17	1	18
12-Jul	16	0	16
13-Jul	9	1	10
14-Jul	7	0	7
15-Jul	35	14	49
16-Jul	11	4	15
17-Jul	6	0	6
18-Jul	5	0	5
19-Jul	2	1	3
20-Jul	4	2	6
21-Jul	10	2	12
22-Jul	4	1	5
23-Jul	62	7	69
24-Jul	55	19	74
25-Jul	13	5	18
26-Jul	34	13	47
27-Jul	13	5	18
28-Jul	1	1	2
29-Jul	2	1	3
30-Jul	6	2	8
31-Jul	5	4	9

Table 6 (continued). The upsteam migration of Atlantic salmon through the counting fence on Campbellton I

Date	Small	Large	Total
01-Aug	1	0	1
02-Aug	2	0	2
03-Aug	1	0	1
04-Aug	1	1	2
05-Aug	2	2	4
06-Aug	5	6	11
07-Aug	3	1	4
08-Aug	2	0	2
09-Aug	2	0	2
10-Aug	1	0	1
11-Aug	0	0	0
12-Aug	5	1	6
13-Aug	54	46	100
14-Aug	19	7	26
15-Aug	14	6	20
16-Aug	3	2	5
17-Aug	21	14	35
18-Aug	91	23	114
19-Aug	56	11	67
20-Aug	8	0	8
21-Aug	3	0	3
22-Aug	1	0	1
23-Aug	5	1	6
24-Aug	11	9	20
25-Aug	2	0	2
26-Aug	4	1	5
27-Aug	27	4	31
28-Aug	10	1	11
29-Aug	2	0	2
30-Aug	59	31	90
31-Aug	122	28	150
01-Sep	8	0	8
02-Sep	2	0	2
03-Sep	5	1	6
04-Sep	4	2	6
05-Sep	1	1	2
06-Sep	2	0	2
07-Sep	2	1	3
08-Sep	1	0	1
Total	1975	321	2296

Table 7. Upstream migration of adult Atlantic salmon through the counting facility on the Campbellton River, 1993-97.

Dates		Standard week	1993		1994		1995		1996		1997		1993 - 97		
			Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Total	Mean	Percent
June	04-10	23							33	9			42	8	0.25
	11-17	24	14	0	3	0	4	2	405	42	16	6	492	98	2.98
	18-24	25	217	6	234	28	322	28	729	57	317	16	1954	391	11.83
	25-01	26	1023	40	525	11	867	30	737	97	450	12	3792	758	22.97
July	02-08	27	1351	42	721	22	693	13	645	161	284	1	3933	787	23.82
	09-15	28	727	25	353	15	279	4	439	120	113	19	2094	419	12.68
	16-22	29	340	12	215	19	394	35	93	46	42	10	1206	241	7.30
	23-29	30	155	7	538	47	297	45	69	18	180	51	1407	281	8.52
August	30-05	31	59	1	118	18	78	23	37	6	18	9	367	73	2.22
	06-12	32	53	4	114	17	39	23	10	3	18	8	289	58	1.75
	13-19	33	25	3	16	7	40	11	11	1	258	109	481	96	2.91
	20-26	34	17	2	13	1	19	4			34	11	101	20	0.61
	27-02	35	12	0	3	3	3	0			230	64	315	63	1.91
September	03-09	36	8	3	4	3					15	5	38	8	0.23
Total			4001	145	2857	191	3035	218	3208	560	1975	321	16511	3302	
Percent			95.5	3.5	93.7	6.3	93.3	6.7	85.0	15.0	86.02	13.98			
Start date for fence			10-Jun		13-Jun		14-Jun		03-Jun		13-Jun				
End date for fence			07-Sep		12-Sep		29-Aug		20-Aug		08-Sep				

Table 8. River age and percent of sampled smolts from 1993-97 applied to the downstream smolt migrations for Campbellton River, 1993-97.

	River age and percent										
Year	2	%	3	%	4	%	5	%	6	%	Total
93	0	0.00	15,710	49.75	15,233	48.24	635	2.01	0	0.00	31,577
94	208	0.50	24,952	59.89	13,199	31.68	3,096	7.43	208	0.50	41,663
95	191	0.48	24,774	62.38	13,805	34.76	945	2.38	0	0.00	39,715
96	543	0.93	34,479	59.07	20,359	34.88	2,988	5.12	0	0.00	58,369
97	230	0.37	35,679	57.50	24,547	39.56	1,365	2.20	230	0.37	62,050
Mean	210	0.45	26,969	57.78	17,666	37.85	1,741	3.73	84	0.18	46,675

Table 9. Biological characteristics of small salmon sampled in the recreational fishery at Campbellton River, 1992-96.

		Fork length (cm)					Whole weight (kgs)					River age (years)				
Year	Sex	Mean	Number	STD	Min	Max	Mean	Number	STD	Min	Max	Mean	Number	STD	Min	Max
92	Male	55.88	4	3.97	52.0	60.0	1.83	3	0.58	1.50	2.50	3.50	4	1.00	3	5
	Female	53.65	13	4.93	43.5	62.5	1.75	2		1.75	1.75	3.38	13	0.51	3	4
	All	54.18	17	4.71	43.5	62.5	1.81	4	0.47	1.50	2.50	3.41	17	0.62	3	5
93	Male	53.03	23	3.50	48.0	62.0	1.55	23	0.29	1.16	2.50	3.09	23	0.29	3	4
	Female	52.42	64	2.49	46.0	57.5	1.47	61	0.22	0.76	1.92	3.03	61	0.36	2	4
	All	52.58	87	2.78	46.0	62.0	1.49	84	0.25	0.76	2.50	3.05	84	0.34	2	4
94	Male	55.76	10	3.13	52.5	60.5	1.79	10	0.36	1.40	2.31	3.17	12	0.39	3	4
	Female	52.71	31	3.13	46.3	59.5	1.56	28	0.28	0.94	2.16	3.25	32	0.51	3	5
	All	53.45	41	3.36	46.3	60.5	1.62	38	0.31	0.94	2.31	3.23	44	0.48	3	5
95	Male	53.69	10	3.55	49.0	61.0	1.72	9	0.38	1.13	2.30	3.30	10	0.48	3	4
	Female	52.47	45	3.44	43.0	62.0	1.55	38	0.32	0.97	2.42	3.30	44	0.51	2	4
	All	52.69	55	3.46	43.0	62.0	1.58	47	0.33	0.97	2.42	3.30	54	0.50	2	4
96	Male	50.63	3	1.87	48.5	52.0	1.44	3	0.10	1.33	1.50	3.50	2	0.71	3	4
	Female	51.50	6	4.23	45.0	55.0	1.58	5	0.41	1.10	2.10	3.33	6	0.52	3	4
	All	51.21	9	3.50	45.0	55.0	1.53	8	0.33	1.10	2.10	3.38	8	0.52	3	4
97	Male	53.05	4	3.81	49.5	58.0	1.65	4	0.35	1.23	2.00	3.50	4	0.58	3	4
	Female	52.08	18	3.96	40.0	56.5	1.43	17	0.28	0.91	1.93	3.33	18	0.49	3	4
	All	52.26	22	3.86	40.0	58.0	1.48	21	0.30	0.91	2.00	3.36	22	0.49	3	4
92-97	Male	53.74	54	3.56	48.0	62.0	1.64	52	0.34	1.13	2.50	3.22	55	0.46	3	5
	Female	52.51	177	3.27	40.0	62.5	1.51	150	0.27	0.76	2.42	3.21	174	0.47	2	5
	All	52.80	231	3.37	40.0	62.5	1.54	202	0.03	0.76	2.50	3.21	229	0.47	2	5

Table 10. River age and percent of salmon sampled in the recreational fishery at Campbellton River, 1992-97.

	River Age								
	2		3		4		5		
Year	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Total
1992	0		11	64.71	5	29.41	1	5.88	17
1993	3	3.57	74	88.10	7	8.33	0		84
1994	0		35	79.55	8	18.18	1	2.27	44
1995	1	1.85	36	66.67	17	31.48	0		54
1996	0		5	62.50	3	37.50	0		8
1997	0		14	63.64	8	36.36	0		22
Total	4	1.75	175	76.42	48	20.96	2	0.87	229

Table 11. Percent male and female of salmon sampled in the recreational fishery for Campbellton River 1992-97.

	Male		Female	
Year	Number	Percent	Number	Percent
92	4	23.53	13	76.50
93	23	27.38	61	72.60
94	12	27.27	32	72.73
95	10	18.52	44	81.48
96	2	25.00	6	75.00
97	4	18.18	18	81.82
Mean	55	24.02	174	75.98

Table 12. Mean fork length, whole weight and river age of salmon smolts sampled from the smolt fence at Campbellton River, 1993-97.

Sex	Fork length (cm)					Whole weight (grams)					Mean river age (yrs)				
	Mean	Nunber	STD	Min.	Max.	Mean	Number	STD	Min.	Max.	Mean	Nunber	STD	Min.	Max.
Male	17.3	311	1.97	13.3	27.5	47.9	311	19.3	18.9	188.2	3.52	311	0.62	3	6
Female	17.4	790	2.03	12.7	27.8	49.4	790	19.7	18.3	206.9	3.43	788	0.57	2	6
All	17.4	1101	2.01	12.7	27.8	49.0	1101	19.6	18.3	206.9	3.45	1099	0.59	2	6

Table 13a. Summary of assessment of Campbellton River salmon stock based on upstream migrating adults.
Based on a conservation requirement of 2,916,000 eggs.

Year	Fence count		Angling catch and mortality				Spawning escapement		Mean WW female		Percent female		Fecundity (eggs/kg)		Egg deposition		Total	Percent of
	Small	Large	Small	Mortality	Large	Mortality	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large		Conservation requirem
93	4001	145	316	10	0	0	3685	145	1.47	3.13	73.56	76.90	2100	2100	8,367,888	732,922	9,100,810	312
94	2857	191	340	0	0	0	2517	191	1.56	3.13	72.73	76.90	2100	2100	5,997,092	965,436	6,962,527	239
95	3035	218	393	5	0	0	2637	218	1.55	3.13	81.82	76.90	2100	2100	7,022,967	1,101,911	8,124,877	279
96	3208	560	463	9	0	3	2736	551	1.58	3.13	66.67	76.90	2100	2100	6,052,335	2,785,105	8,837,440	303
97	1975	321	238	6	0	1	1731	315	1.43	3.13	81.82	76.90	2100	2100	4,253,162	1,592,211	5,845,372	200

Table 13b. Summary of assessment of Campbellton River salmon stock based on downstream migrating kelts from the next year.
Based on a conservation requirement of 2,916,000 eggs.

Year	Fence count		Angling catch and mortality				Spawning escapement		Mean FL kelts		Percent female		Fecundity (eggs/cm)		Egg deposition		Total	Percent of
	Small	Large	Small	Mortality	Large	Mortality	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large		Conservation requirem
93	4001	145	316	10	0	0	3675	145	52.03	65.17	73.56	76.90	59.97	59.97	8,435,036	435,789	8,870,825	304
94	2857	191	340	0	0	0	2517	191	53.25	65.00	72.73	76.90	59.97	59.97	5,845,888	572,542	6,418,429	220
95	3035	218	393	5	0	0	2637	218	52.33	68.37	81.82	76.90	59.97	59.97	6,771,025	687,357	7,458,382	256
96	3208	560	463	9	0	3	2736	557	52.04	69.03	66.67	76.90	59.97	59.97	5,692,695	1,773,183	7,465,877	256
97	1975	321	238	6	0	1	1731	320			81.82	76.90	59.97	59.97				

Note: Mean fork length of kelts are applied to previous year data to represent upsteam migrating fish

Table 14. Sea survival rates for salmon on the Campbellton River from 1994-97.

Percent survival	1997	1996	1995	1994	Mean % 94-97
Smolt to Small salmon uncorrected	3.38	8.08	7.28	9.05	6.95
Overwintering of previous spawners	70.05	68.92	69.20	74.10	70.57
Previous spawners survival 3 months	38.96	39.42	34.85	25.58	34.70
Smolt to small salmon corrected	2.25	7.15	6.08	7.24	5.68

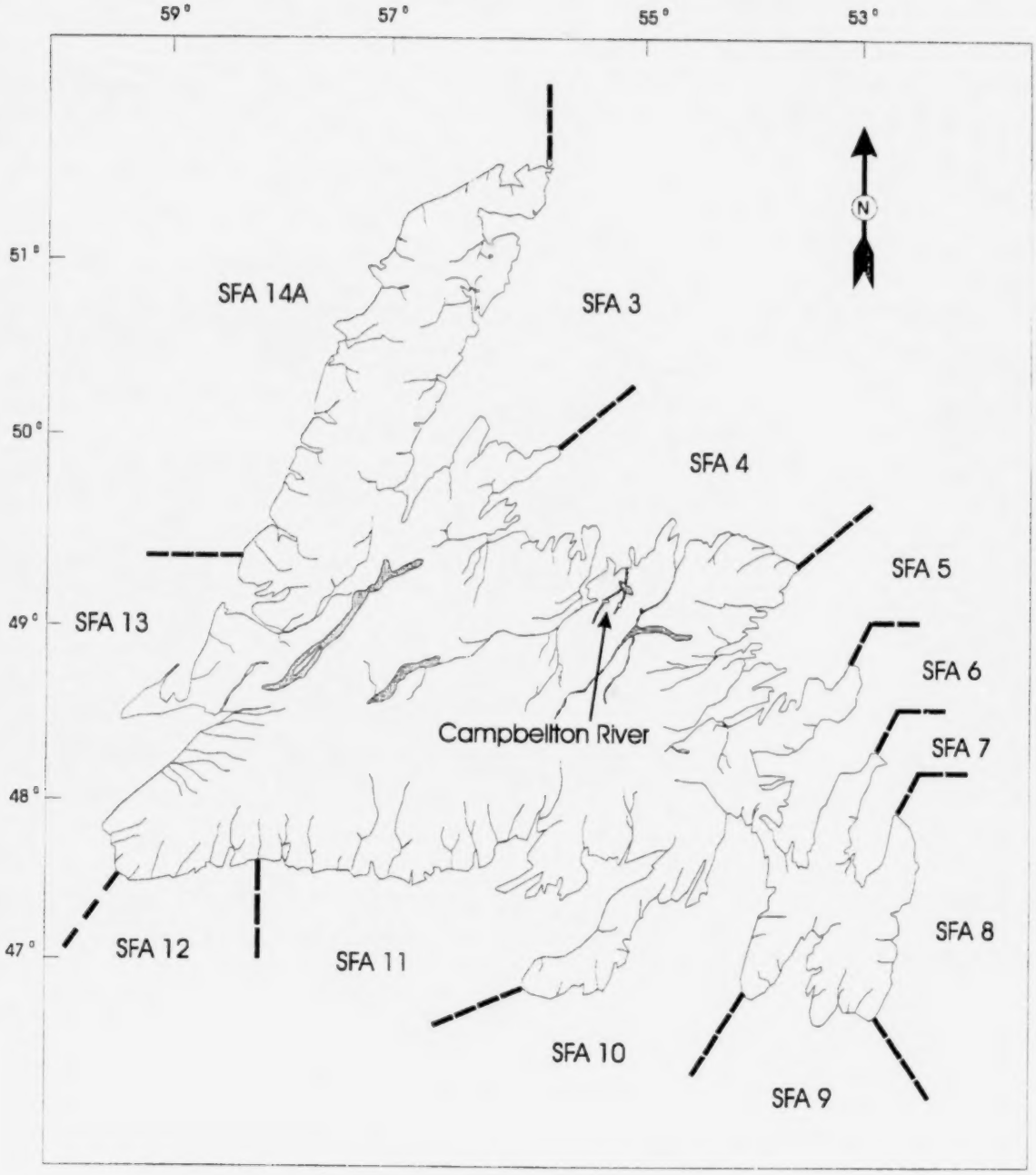


Figure 1. Salmon Fishing Areas on the Island of Newfoundland with reference to the the Campbellton River.

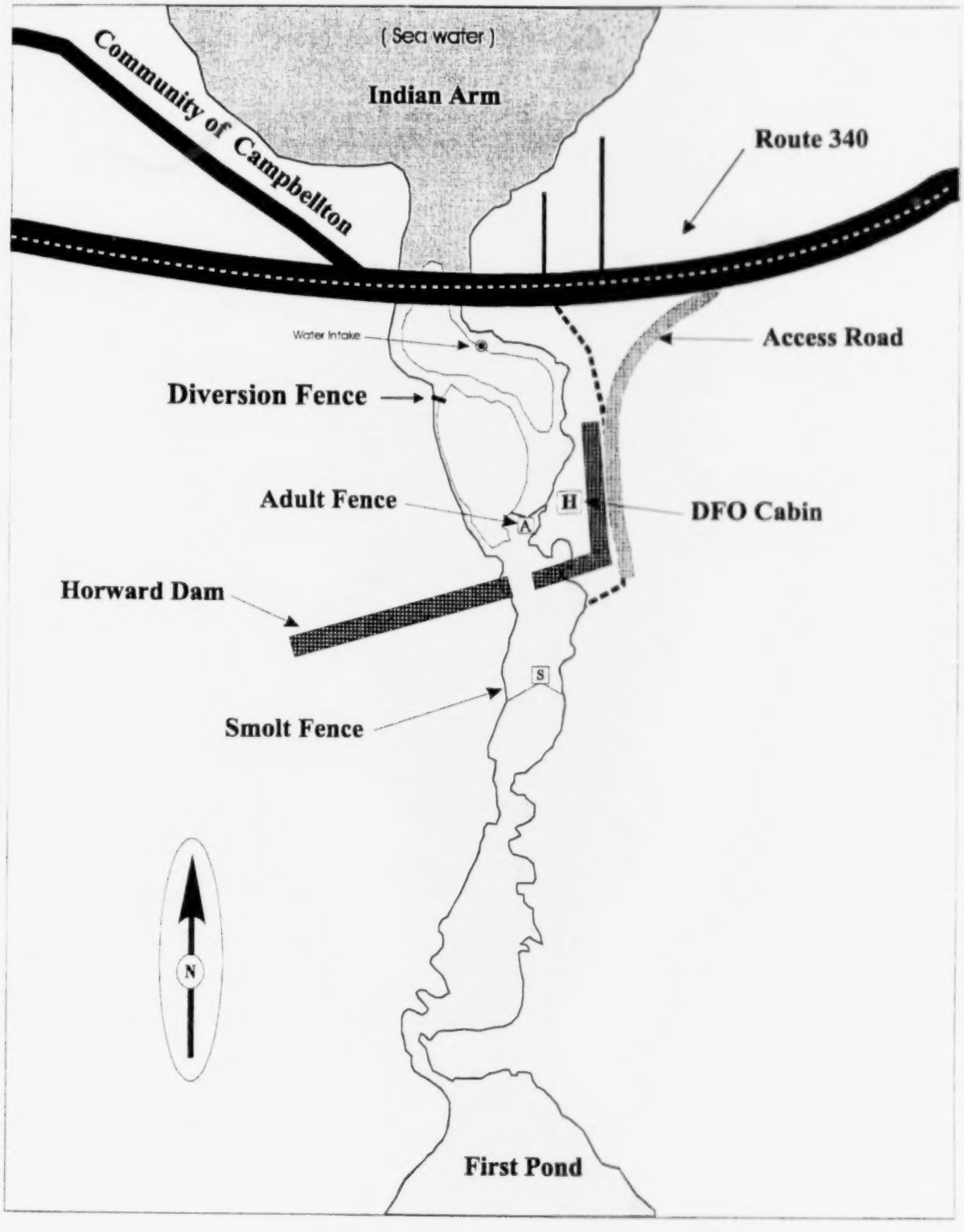
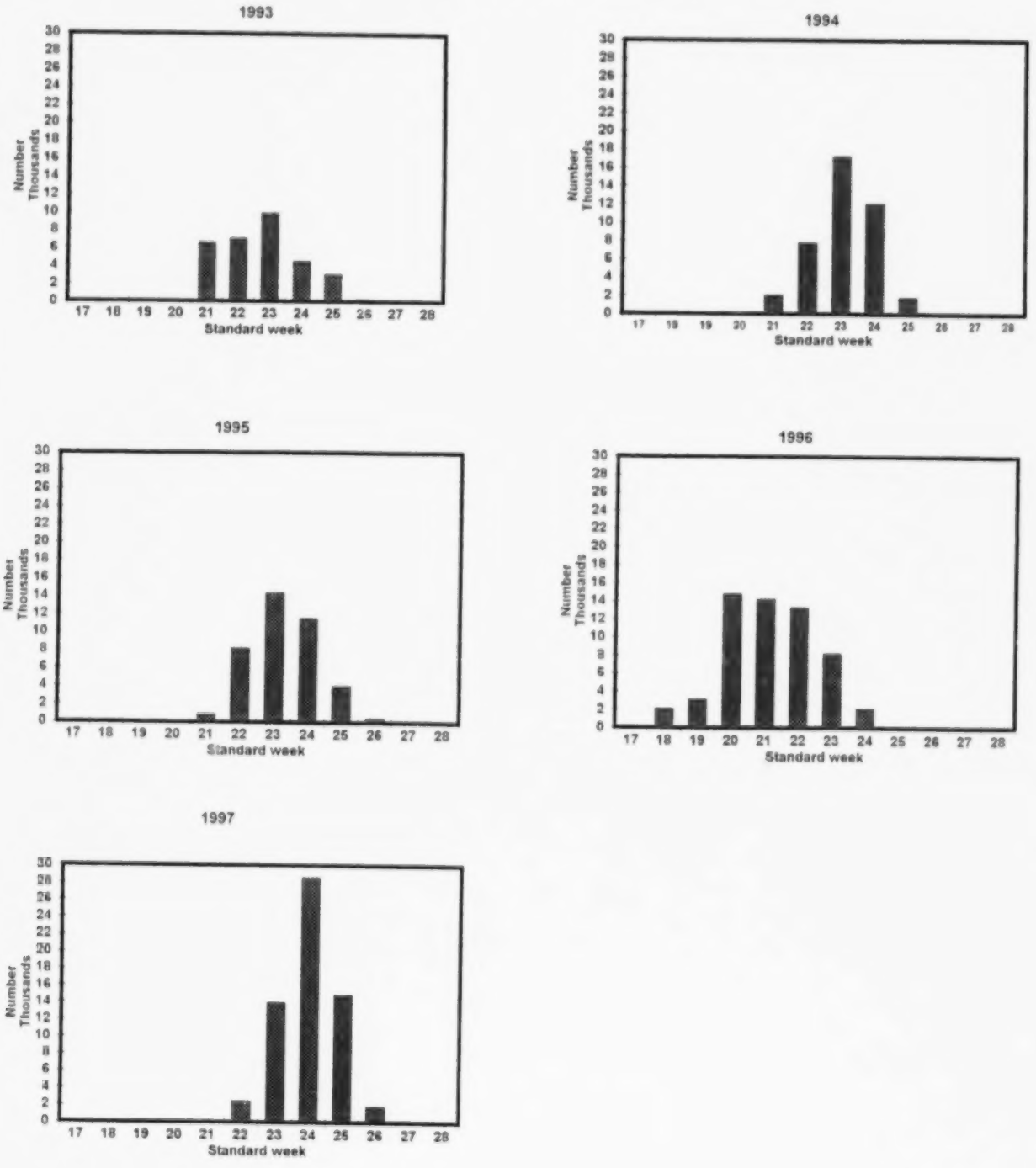


Figure 2. Campbellton River showing locations of Smolt and Adult Counting Fences.

Figure 3. Downstream smolt migration at Campbellton River 1993 - 97.



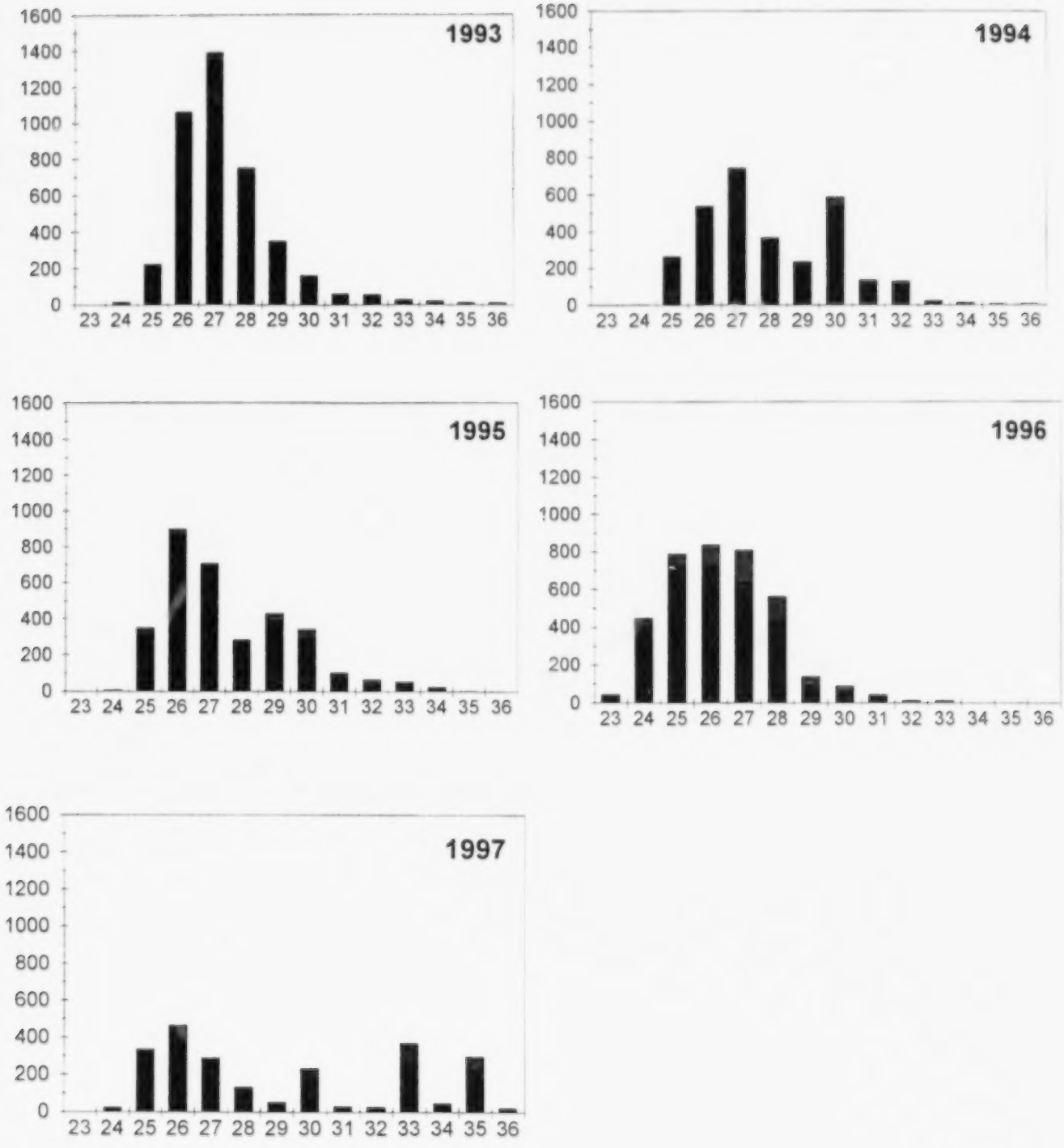


Figure 4. Adult salmon upstream migration enumerated at the counting fence for Campbellton River 1993-97.

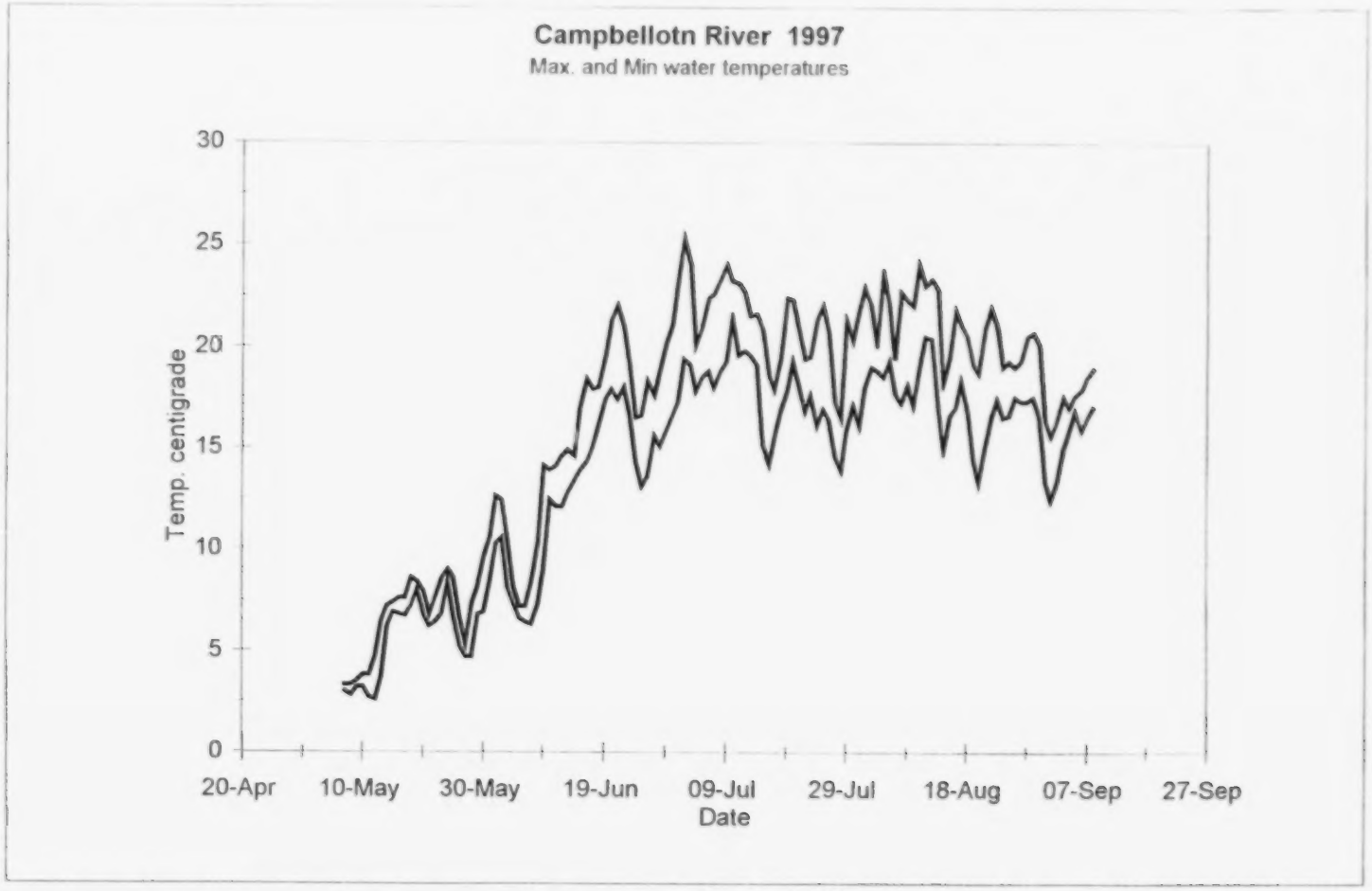


Figure 5. Maxium and minium daily water temperatures for Campbellton River 1997.

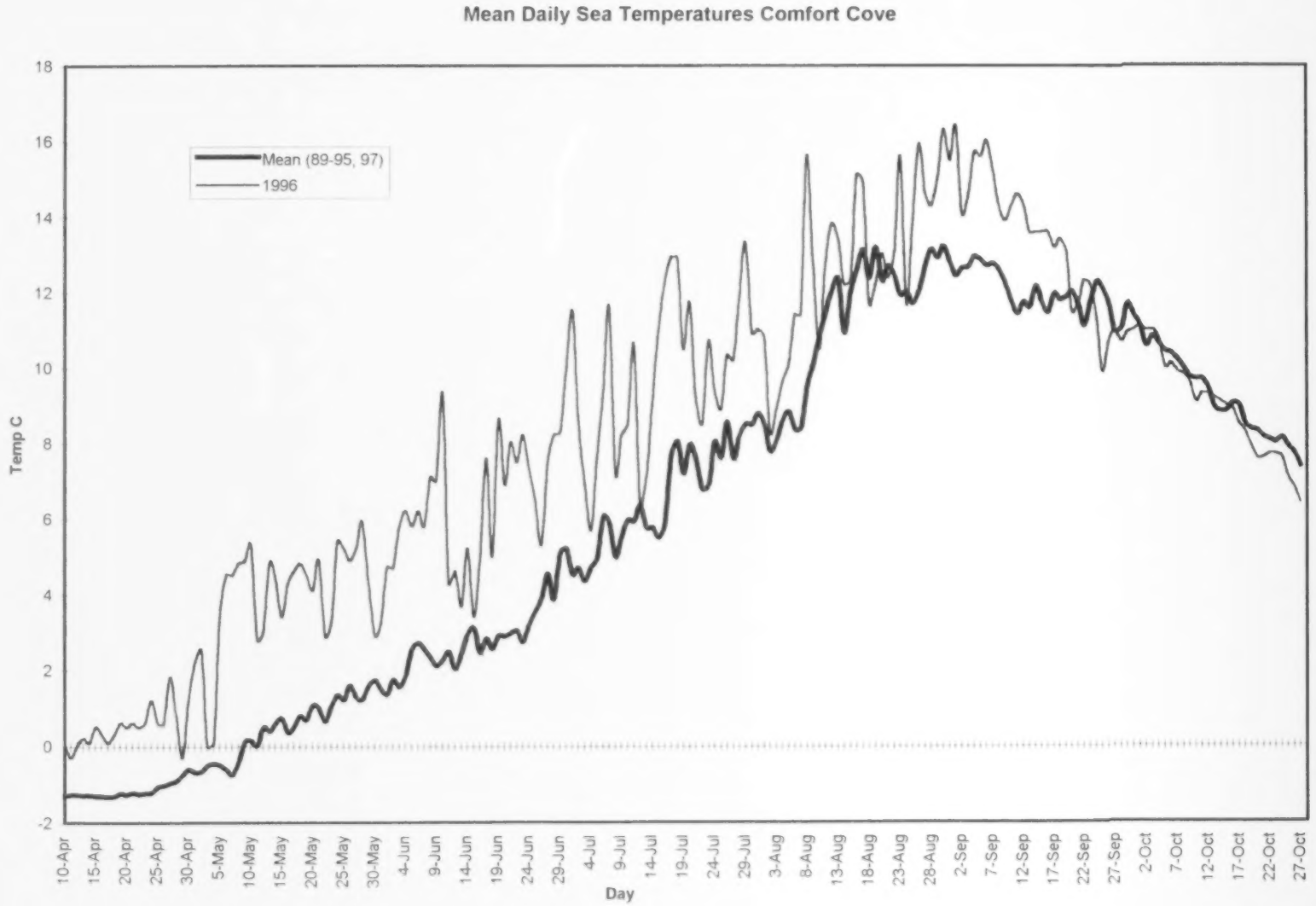


Figure 6. Mean daily sea temperatures for Comfort Cove 1989-95,97 and 1996.

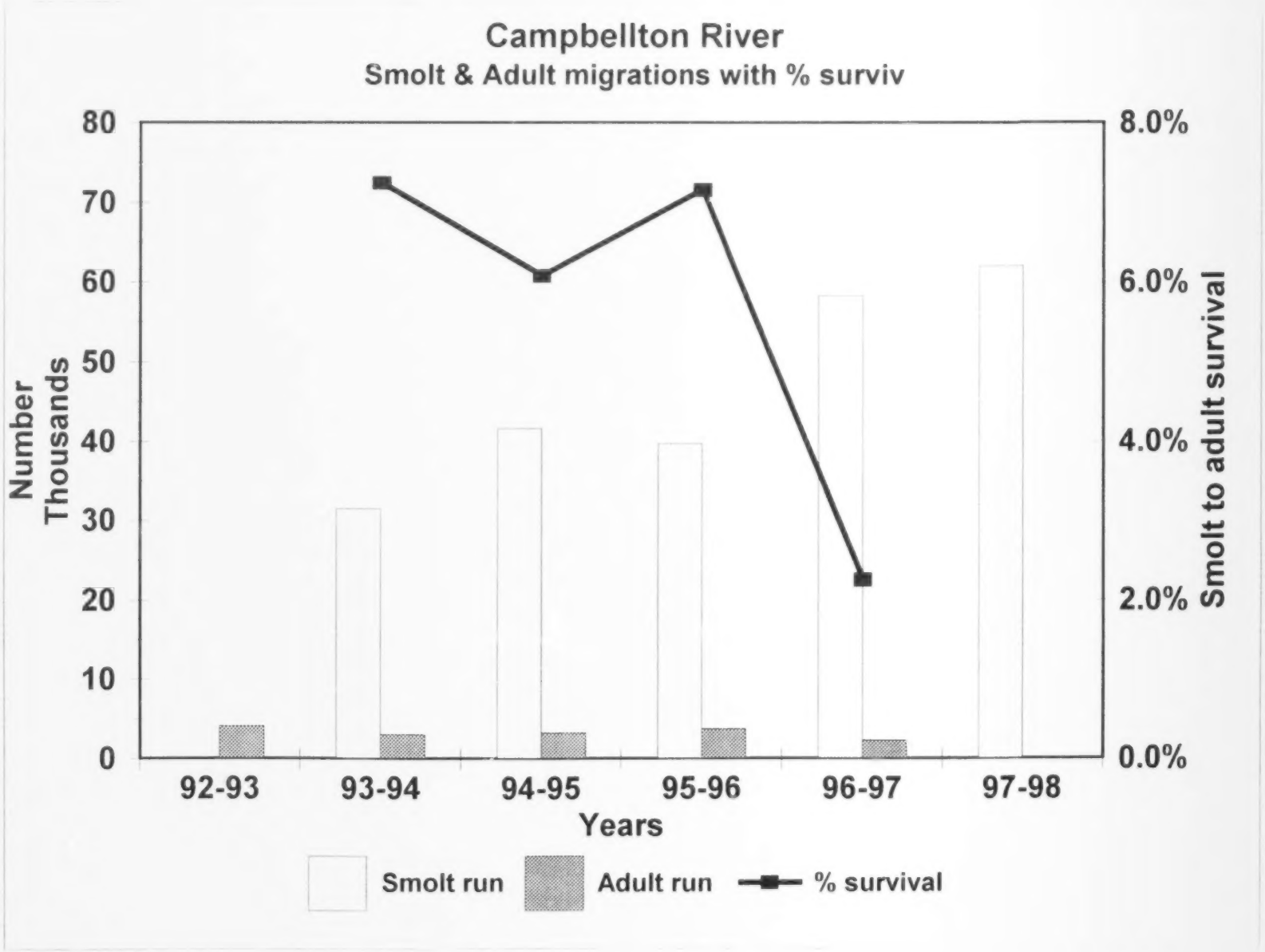


Figure 7. Salmon migrations and smolt survival for Campbellton River 1994-97.

APPENDIX 1

Sea survival rates for Campbellton River salmon

1994

Sea survival rates for 93 smolt class:

Smolt count - 93		= 31,577
Adult count (small only) - 94		= 2,857
Sea survival rate - 93	*(2,857 / 31,577)*	= 9.05 % (uncorrected)

Previous spawners:

Kelts (downstream) - 94		= 2,838
Tagged kelts (downstream) - 94 (first year of kelt tagging)		= 942
Ratio untagged : tagged (total)	*(2,838 / 942)*	= 3.01
Overwintering survival- 93 to 94 with the recreational catch removed	*(2,838 / (4,146-316))*	= 74.10 %

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '94	Percent previous spawners
Small	190	572	2,857	20.0
Large	51	154	191	80.6
Total	241	726	3,048	23.8

Sea survival rates with correction for previous spawners:

Smolt count - 93		= 31,577
Upstream grilse - 94	*(2,857-572)*	= 2,285
Previous spawners survival 3 mo	*(726 / 2,838)*	= 25.58 %
Corrected smolt sea survival - 93	*(2,285 / 31,577)*	= 7.24 %

APPENDIX 2

Sea survival rates for Campbellton River salmon

1995

Sea survival rates for 94 smolt class:

Smolt count - 94		= 41,663
Adult count (small only) - 95		= 3,035
Sea survival rate - 94	*(3,035 / 41,663)*	= 7.28 % (uncorrected)

Previous spawners:

Kelts (downstream) - 95		= 1,874
Tagged kelts (downstream) - 95 (448 tagged in '95 & 152 from '94)		= 600
Ratio untagged : tagged (total)	*(1,874 / 600)*	= 3.12
Overwintering survival- 94 to 95 with the recreational catch removed	*(1,874 / (3,048-340))*	= 69.20 %

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '95	Percent previous spawners
Small	160	500	3,035	16.5
Large	49	153	218	70.2
Total	209	653	3,253	20.1

Sea survival rates with correction for previous spawners:

Smolt count - 94		= 41,663
Upstream grilse - 95	*(3,035-500)*	= 2,535
Previous spawners survival 3 mo	*(653 / 1,874)*	= 34.85 %
Corrected smolt sea survival - 94	*(2,535 / 41,663)*	= 6.08 %

APPENDIX 3

Sea survival rates for Campbellton River salmon

1996

Sea survival rates for 95 smolt class:

Smolt count - 95		= 39,715
Adult count (small only) - 96		= 3,208
Sea survival rate - 95	*(3,208 / 39,715)*	= 8.08 % (uncorrected)

Previous spawners:

Kelts (downstream) - 96		= 1,971
Tagged kelts (downstream) - 96 (484 tagged in '96 & 100 from '94-95)		= 584
Ratio untagged : tagged (total)	*(1,971 / 584)*	= 3.38
Overwintering survival- 95 to 96 with the recreational catch removed	*(1,971 / (3,253-393))*	= 68.92 %

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '96	Percent previous spawners
Small	109	368	3,208	11.5
Large	121	409	560	73.0
Total	230	777	3,768	20.6

Sea survival rates with correction for previous spawners:

Smolt count - 95		= 39,715
Upstream grilse - 96	*(3,208-368)*	= 2,840
Previous spawners survival 3 mo	*(777 / 1,971)*	= 39.42 %
Corrected smolt sea survival - 95	*(2,840 / 39,715)*	= 7.15 %

APPENDIX 4

Sea survival rates for Campbellton River salmon

1997

Sea survival rates for 96 smolt class:

Smolt count - 96		= 58,369
Adult count (small only) - 97		= 1,975
Sea survival rate - 96	*(2,857 / 58,369)*	= 3.38 % (uncorrected)

Previous spawners:

Kelts (downstream) - 97		= 2,315
Tagged kelts (downstream) - 97 (347 tagged in '97 & 112 from '94-96)		= 459
Ratio untagged : tagged (total)	*(2,315 / 459)*	= 5.04
Overwintering survival- 96/97 with the recreational catch removed	*(2,315 / (3,768-463))*	= 70.05%

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '97	Percent previous spawners
Small	131	660	1,975	33.4
Large	48	242	321	75.4
Total	179	902	2,296	39.3

Sea survival rates with correction for previous spawners:

Smolt count - 96		= 58,369
Upstream grilse - 97	*(1,975-660)*	= 1,135
Previous spawners survival 3 mo	*(902 / 2,315)*	= 38.96%
Corrected sea smolt survival - 96	*(1,315 / 58,369)*	= 2.25%